



TRIBOLOGY: A Systems Approach to the Science and Technology of Friction, Lubrication and Wear, by Horst Czichos. Tribology Series, 1, Elsevier Scientific Publishing Company, Amsterdam-Oxford-New York, 1978, 400 pp., 164 figures, 36 tables, 430 references, \$49.50.

REVIEWED BY W. O. WINER¹

Before receiving Czichos' book I had the good fortune to read *An Introduction to General Systems Thinking* by Gerald M. Weinberg.² It helped form a viewpoint from which to assess Czichos' book and increased my appreciation for it. We are told by general systems concepts that systems analysis is intended for medium sized problems; systems of "organized complexity"; systems that are too complex for classical mechanics analysis and too organized for the statistical analysis applied to large populations. Everyone working in the field of tribology knows, at least intuitively, that real world tribology systems are multi-component systems with multiple interactions requiring a multi-disciplinary approach to understand. They are a form of "organized complexity". A major objective of systems analysis is to assist us in recognizing, describing and analyzing these medium sized problems. In this respect Czichos has performed an excellent service for the tribology community.

The field of tribology is multidisciplinary. Unfortunately this leads to the tendency for those of each discipline to perceive and try to solve, tribological problems in terms of their own discipline. This in turn leads to fragmentation of our knowledge and efforts rather than integration of them which is required to solve the applied problems facing the typical tribologist. The tribology literature also is by and large composed of writings in each discipline.

In his preface, Czichos opens by stating "This volume gives a systematic unified approach to tribology: the fundamentals of friction, lubrication and wear and their influences on the structure and function of dynamic mechanical systems." This is indeed an enormous task and one which he has accomplished admirably. He has managed to take this field in which every situation seems like a special case, and methodically put the pieces of the puzzle together to the point where the reader begins to see a coherent picture.

In his introductory chapter he presents an historical development of tribology. Chapter 2 is background for the systems concept in general with particular emphasis on tribology as the subject to which it is applied. I would recommend, as supplemental reading on this chapter, the book by Weinberg previously mentioned. However, most engineers will recognize the ideas from their study in college of systems or control volumes in thermal sciences or free body diagrams in mechanics.

The third chapter is the presentation of a general theory of tribology where the author applies the systems concepts to tribology. He discusses tribo-mechanical systems in terms of their function, their structure, and the many possible component interactions. This chapter may seem rather esoteric for some readers but I would en-

courage them to stay with it because the author is presenting a view of the field which should have significant impact on the future solutions to tribological design problems.

The fourth chapter, "Tribological Processes" was a pleasant surprise for me. It is the longest chapter, has the most references (187) and is a very concise review of the broad field of tribology. I commend it to everyone in the field particularly neophytes even if they think the systems approach will not benefit them (in which case they are probably wrong). In a field which has produced 55,000 publications in the last decade and currently publishing in excess of 8000 per year, it is difficult to get an overview of the state-of-the-art. Czichos has given a good review with extensive references to permit the interested reader to pursue the details.

Chapters 5 and 6 discuss the influences of tribological processes on the structure and function of mechanical systems respectively. They contain many examples of the ways friction, lubrication and wear processes change the structure (components) of the system and therefore change the response or performance (function) of the system.

Chapter 7 presents a short review of tribometry and related test methods available for evaluating tribological systems. Here he also presents a good discussion of the perennial problem of simulative testing in tribology. This is an area where the systems methodology can be very useful.

Chapter 8 is the culmination of the book's objectives: Practical Systems Methodology. Here Czichos specifically and methodically presents details of how to apply the systems concepts. He presents a sample data sheet for cataloging the structure and function of the tribological system of interest to assist in clearly accounting for the many factors involved. He also discusses how research data should be presented to make it more useful and to clearly delineate the limits of applicability. Both are very useful to the recipient of someone else's data. The chapter also contains eight detailed examples of how the methodology was successfully applied. These successes are encouraging but should not be taken to imply that the application of systems methodology will always lead to such a happy ending. We must not forget what Weinberg (1) calls the Law of Medium Numbers: "For medium number systems, we can expect that large fluctuations, irregularities, and discrepancy with any theory will occur more or less regularly". However, the methodology Czichos presents should help reduce that regularity.

As Czichos says (p. 316) "Once this systems thinking is adopted, the application of systems methodology to the solution of tribological problems appears to be a quite straightforward application of technological common sense on a broad scale." In spite of the "common sense" appearance of the methodology, most workers in the field do not apply it and could benefit from the application of it to their thinking and in their publications.

The book gives a good overview of tribology thoroughly referenced (430 references of 350 authors) for the reader who seeks further details. It also contains good author and subject indices. It sets a very high standard for reproduction with author prepared manuscript. The book is intended to be the first in a series on tribology by the publisher. It sets a very high standard for those who follow in the series. If the standard of presentation and relevance of subject matter is maintained in the series, we look forward to additions to the series.

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² Gerald Weinberg, *An Introduction to General Systems Thinking*, Wiley, New York, 1975.

In summary, the book is well written and easy to read. It gives a fresh perspective on research, development, and application in the field of tribology. It should influence thinking and help lead to progress in this complex field. I recommend it to both research persons

and design engineers concerned with any facet of the field of tribology. It should also be brought to the attention of graduate students working in the field. This book will come to be thought of as a significant contribution to tribology.